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ABSTRACT

Among the 12 documents selected for this annotated bibliography of documents and journal articles in the ERIC database is an expert's argument that the brain's multipath and multimodal capacities are ignored by educators. Another writer fears that the "back-to-basics" movement may have eclipsed the prominence earlier accorded to thinking skills. One article outlines obstacles to the effective teaching of thinking skills, and suggests five steps educators can take to improve their teaching. Other entries include a list of 11 criteria that must be met to establish a classroom environment conducive to the development of thinking skills, and a discussion of short- and long-term strategies for strengthening the teaching of critical thinking. Research contributions include a survey of 278 teachers concerning their opinions and practices regarding the teaching of problem-solving skills, and a finding that brainstorming-like sessions significantly enriched biology students' ability to inquire into scientific problems. Accounts of programs include an analysis of the kinds of thinking taught in current programs and a description of a program to teach thinking skills that identifies 34 mental activities. Also included is a description of three computer programs that generate a variety of problems for students to solve as a means of developing higher-level thinking skills. (MLF)

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THE BEST OF ERIC ON EDUCATIONAL MANAGEMENT

Number 77, December 1984

The Best of ERIC presents annotations of ERIC literature on important topics in educational management.

The selections are intended to give educators easy access to the most significant and useful information available from ERIC. Because of space limitations, the items listed should be viewed as representative, rather than exhaustive, of literature meeting those criteria.

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Improving Students' Thinking Skills

1 **Beyer, Barry K.** "Improving Thinking Skills: Defining the Problem" and "Improving Thinking Skills: Practical Approaches." *Phi Delta Kappan,* 65,7 (March 1984), pp. 486-90. EJ 294 947. And 65,8 (April 1984), pp. 556-60. EJ 296 775.

"In a recent poll of professional educators, nine out of ten respondents said that better instruction in thinking skills should be a priority in educational planning for the coming years," reports Beyer. "What can we do," he asks, "to improve the teaching and learning of thinking in our schools?" In the first of these two articles, Beyer outlines obstacles to the effective teaching of thinking skills, and in the second article he suggests five steps educators can take to bring about an improvement.

"There are at least five major reasons why we educators have not put to better use the time we devote to teaching thinking skills," says Beyer. "First, we do not agree among ourselves which thinking skills we should teach." Second is the absence of a precise definition of those skills. Third, "most teachers never actually provide the kinds of instruction that research suggests is most productive in developing competent thinkers."

The fourth reason Beyer gives is the problem of "skills overload": school curricula "bombard students with one-shot exposure to literally dozens of skills at each grade level." Finally, most thinking skills achievement tests are poorly designed and feed teachers' natural tendency to teach to a test.

Beyer's five steps to improve the teaching of thinking skills are logically related to the obstacles he's observed. First, educators need to identify and clearly define a core of thinking skills that they agree should be taught. Second, they need to identify the component parts of each of these skills. Third, they need to provide direct, systematic instruction in the use of these skills in all appropriate content areas. Fourth, they need to structure a thinking skills curriculum that sequences the introduction of a reasonable number of thinking skills in a logical progression from K to 12. Finally, they need to design valid, reliable tests of competency in the use of thinking skills.

2 **Costa, Arthur L.** "Teaching for Intelligent Behavior." *Educational Leadership,* 39,1 (October 1981), pp. 29-31. EJ 253 751.

"What classroom conditions contribute to the development of intelligent behavior?" This opening question reveals that Costa is not so much concerned with programs and curriculums to teach thinking skills as he is with teacher attitudes and practices that can nurture these skills within existing classes. Costa offers eleven criteria that must be met to establish a classroom environment conducive to the development of thinking skills.

Costa says, first, students need to realize that intelligent behavior, as opposed to just getting the right answers, is the objective of education. Second, the teacher's questions and statements in class should call attention to discrepancies and pose problems "intended to invite more than a memory-type response." Third, because "levels of thinking are cumulative," teachers must arrange instructional activities sequentially, giving students adequate time to move from data gathering to processing to higher levels of thinking.

Costa's fourth criterion concerns teachers' responses to student answers. Instead of responding with praise, correction, or other value judgments, which signal conformity, teachers can "facilitate intellectual functioning" by means of silence, extending student ideas, and providing additional information.

Fifth, instructional materials need to support intelligent behavior; they should not be designed merely to be read, memorized, and tested. Sixth, adequate instructional time must be devoted to developing thinking. Seventh, instruction must be diversified to fit students' varying modality strengths—visual, auditory, and tactile; and eighth, these modalities must be sequenced (experience should precede thinking and talking). Ninth, students and teachers need to talk about their thinking, for Costa notes it has been shown that "thinking and talking about thinking begets thinking."

Tenth, evaluation practices should assess intelligent behavior; "the product of assessment should be not what answers the student knows but how the student behaves when he or she doesn't know." Finally, teachers and other significant adults, including administrators, should model intelligent behavior by, for example, "taking a student's point of view," "using reason and patience in dealing with discipline problems," and "planning for instruction."

3 **Drum, Randell L., and Wells, Tim J.** "A Survey of Teachers' Opinions and Practices Regarding the Teaching of Problem Solving Skills." Paper presented at the annual meeting of the American Association of Colleges for Teacher Education, February 1-4, 1984. 38 pages. ED 240 075.

Of 150 elementary level and 450 secondary level teachers in Texas whom Drum and Wells surveyed, 278 responded. Although most teachers expressed the view that problem solving ability was

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important and should be taught in schools, 64 percent said it wasn't stressed in their teacher preparation classes, and 62 percent said it hadn't been stressed in their districts' inservice sessions.

The researchers found that older, more experienced teachers tend to teach problem solving more than do younger, less experienced teachers. Also, teachers who belong to professional organizations are more likely to teach these skills than teachers who don't.

Drum and Wells recommend placing greater emphasis on the teaching of problem solving skills, especially in teacher training courses, but also in district inservices. Districts should also encourage their teachers to participate in professional organizations as a further means of supporting this emphasis.

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4 **Hart, Leslie A.** "The Incredible Brain: How Does It Solve Problems? Is Logic a Natural Process?" *NASSP Bulletin,* 67,459 (January 1983), pp. 36-41. EJ 274 298.

Educators who claim they are teaching students how to think may actually only be teaching them how to solve puzzles. Further, when educators "try to get students to think logically," they may be hindering students' learning process. Hart realizes that what he has to say about traditional approaches to learning "shocks many people because we have been brought up to believe that logic is little short of holy."

An expert on the relation of the brain to education, Hart argues that recently gained knowledge of how the brain functions has placed "some old ideas" of the learning process into disrepute. The brain, he says bluntly, "was not designed for logic," that is, thinking that follows "a simple, linear sequence of steps, each leading to the next." Whereas logic goes down a single path, "the brain operates along many paths simultaneously." Hart says, "If I suddenly hand you a coconut, you do not have to consider first its size, then weight, then color, then texture, and so on—the brain automatically goes down all those paths and more, and promptly decides, 'this is probably a coconut'."

But when teaching students, educators commonly have ignored the brain's multipath and multimodal (ability to use vision, hearing, touch, etc., simultaneously) capacities. Educators who learned such things as managing personal finances or writing essays in "a random style" are likely to try to teach those things in an order that they "can claim is logical," while the school likely demands "a logical lesson plan." As Hart says, "We do not teach the way we ourselves learned, but in just the opposite fashion."

Problems students are asked to solve are usually "artificial and unrealistic...more properly called puzzles." Information is neatly provided; there is only one right answer; and "most often a logical solution is asked for or implied, and the student must demonstrate how the solution was reached."

These "brain-antagonistic" educational settings and methods must be replaced, Hart pleads, with approaches that are "brain-compatible." Learning is a gradual process in which "the brain builds on its own experience." Hart suggests that the best approach may be to assign students to work out the solution to a real problem of interest to them, such as designing "an ideal home study desk" or "a system to finance school sports."

In guiding students toward the solution, the teacher can suggest useful strategies: define the answer so we will "know if we have solved it"; consider alternative approaches; evaluate all information "bit by bit"; and "then give the incredible brain opportunity to solve it—in its own way and its own time."

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5 **Hensen, J. Merrill.** "Thinking Skills in the Classroom: A Needed Basic in Education." *Clearing House,* 56,2 (October 1982), pp. 60-63. EJ 269 780.

In 1961 the Educational Policies Commission proposed that "the central purpose of the schools was to develop the rational powers of students." Yet Hansen fears the popularity of the "back-to-basics" movement may have eclipsed the prominence shown to thinking skills. Mastery of facts in isolation is insufficient, asserts Hansen, because facts don't exist in isolation, but rather are interrelated. Therefore the thinking skills necessary to manipulate, analyze, and synthesize information are also basic to education.

Thinking skills include such functions as concept formation, interpreting, inferring, generalization, and application of principles. Hansen says that these skills can be encouraged across the curriculum in all subjects that are taught. Classroom teachers can encourage the development of thinking skills both in the mode of their presentation and in the variety of their learning activities. "Children should learn to perform a number of intellectual operations such as solving problems efficiently, describing phenomena accurately, and analyzing ideas rigorously."

Hansen concludes: "True mastery includes the ability to think 5o-3 about the 'how?' and the 'why?' as well as the 'what?'."

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6 **Lazarowitz, Reuven, and Huppert, Yehuda.** "Developing Creative Thinking Skills in Secondary School Biology Students." *American Biology Teacher,* 42,4 (April 1980), pp. 226-28. Ej 222 498.

"Suppose you are working in a drug factory and you receive a grant for developing an effective medicine against a specific disease. What are the data that you will look for before you start to carry out scientific experiments for developing such a medicine?" Lazarowitz and Huppert gave this problem to two groups of high school biology students to see what effect different teaching approaches would have on their students' problem solving ability.

In the previous unit of study concerning the life of bacteria and cell staining techniques, the experimental group was presented with a problem and then encouraged to offer as many ideas, suggestions, reactions, and hypotheses as possible. The teacher guided and encouraged the discussions to keep them going in fruitful directions. The control group, on the other hand, was conducted with regular classroom-laboratory instruction techniques. Student participation was encouraged only as far as it was necessary for mastery of the subject content.

When these same groups were given the above problem, student answers were analyzed for fluency (how many answers), flexibility (how many different kinds of answers), and originality (answers not given by any other students). It was found that the experimental group generated more possible factors, of greater diversity, and with more originality. For example, eight original answers were generated by the experimental group as opposed to one by the control group. The authors concluded that the training of students to "conduct open, broad discussions, similar to brainstorming sessions" significantly enriched their ability to inquire into scientific problems.

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7 **Nickerson, Raymond S.** "Kinds of Thinking Taught in Current Programs." *Educational Leadership,* 41,1 (September 1984), pp. 26-36. EJ number not yet assigned.

Some thinking-skills programs emphasize what Nickerson terms "cognitive-process approaches." These "assume that thinking ability depends on fundamental processes such as comparing, ordering, classifying, inferring, and predicting."

Other programs emphasize "heuristic-oriented approaches." (Nickerson defines a heuristic as "an approach to a goal that is believed to have a good chance, but not certainty, of success.") Examples of heuristics for problem solving are representing a problem with a diagram or graph, restating or reformulating the problem, and breaking down the problem into smaller parts.

Still other programs reflect Jean Piaget's view that cognitive

development occurs in stages and that the ability to perform formal or abstract operations normally is acquired after the ability to perform concrete operations. These programs seek to bring students stuck in the concrete operations stage into the formal operations stage.

Finally, the Philosophy for Children program is a good example of a program that seeks to develop thinking skills by getting students to think about the characteristics of good and bad thinking.

Related to these programs for the teaching of thinking are writing textbooks that view writing not only as a vehicle for thought, but also as a means of developing it. Similarly, the teaching of computer programming, especially with the language LOGO, is "prototypical of many cognitively demanding tasks."

8 **O'Brien, Thomas C.** "Software of the Second-and-a-Half Kind." *Classroom Computer Learning*, 4,2 (September 1983), pp. 33-34, 36. EJ 287 202.

Software of the second-and-a-half kind is educational software that neither uses the computer as a tutor for tutorials and practice, nor uses it as a tool for such purposes as word processing, nor even uses it for discovery purposes such as with Logo, but rather uses the computer to randomly generate a variety of problems for the students to solve as a means of developing higher level thinking skills. The three programs described here are Billiard Ball, Taxman, and Teasers by Tobbs. Each program gives students different kinds of math problems that require them to utilize different problem solving strategies.

In Billiard Ball students must use such thinking skills as planning ahead, analyzing, using a model, and identifying patterns. "In Taxman, students use and extend their knowledge of factors, primes and divisibility. More importantly, they construct, test, and refine a strategy," says O'Brien. And Teasers by Tobbs "helps the student invent and practice several problem-solving skills: working backwards to solve a problem, working within the constraints of a problem, developing chains of thought and following them to their conclusion, not to mention deciding how to approach a problem."

O'Brien notes that these kinds of activities can be done with paper and pencil, too, but the speed with which the computer can generate problems, and the patience of the computer in letting students explore one approach and then try again are attributes that may facilitate these kinds of activities becoming a regular part of the curriculum.

9 **Olson, Lynn.** "On Aristotle, Pixie, and the Art of 'Logical Talk'." *Education Week*, September 5, 1984, pp. L17, L67-68. EJ number not yet assigned.

By "basic skills" educators usually mean reading, writing, and arithmetic. Some, however, suggest that thinking and reasoning skills are even more basic to students' educational success. Matthew Lipman asserts in this interview that reading and writing are dependent on thinking skills; he has therefore developed a program called Philosophy for Children to enhance those skills at both the elementary and the secondary level.

In trying to define "thinking skills," Lipman and his colleagues have come up with 34 mental activities such as making inferences, deciding, remembering, making distinctions, and detecting part/whole fallacies. The way to teach these components, he believes, is to enwrap them in contexts that are interesting and meaningful to children and young adults. Novels provide such a context. Lipman tries to make sure that the issues dealt with at each grade level are relevant to students at that level.

Student participation is essential; Lipman believes that children learn through discussion. As they listen to each other, challenge assumptions, and discern inferences in the midst of purposeful, guided discussions, they are internalizing thinking skills.

When Lipman and his colleagues taught thinking skills to an experimental group of students for a period of 8 months, these students gained 14.5 months in reasoning ability (as measured by the New Jersey Test of Reasoning Skills), compared with a control group that gained an average of 8 months.

10 **Paul, Richard W.** "Critical Thinking: Fundamental to Education for a Free Society." *Educational Leadership*, 41,1 (September 1984), pp. 5-14. EJ number not yet assigned.

The topic of critical thinking is increasingly becoming one that school administrators can't ignore. According to Paul, the California State Department of Education is preparing to test critical thinking skills as part of its test of reading, written expression, math, and social studies abilities for all eighth-grade pupils. How can teachers and school systems help their students meet these new mandated requirements?

Paul advocates short-term and long-term strategies for strengthening the teaching of critical thinking. The short-term strategy involves the teaching of critical/analytical vocabulary such as premise, reason, conclusion, inference, and so forth within the regular content curriculum where these terms can be applied appropriately as they are learned. The realization of this strategy will require teacher training and the acquisition of appropriate resources.

Paul advises school officials to make available nationally normed tests such as the Watson-Glasser and the Cornell Critical Thinking Test so that teachers can refer to them as models of test questions. Teachers should also be encouraged to attend professional conferences on this topic. Administrators can help further by establishing a schoolwide attitude favorable to reasoning through conflicts to problem solution, says Paul.

Paul's long-term strategy is to develop a "dialectical" approach

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to problem solution. This involves what he terms "dialogical reasoning"—thinking critically and reciprocally within opposing points of view. This ability to detach oneself in order to really "hear" opposing lines of reasoning is very much intrinsic to our character and is therefore not a skill that can be taught in a six-week unit. It is also quite distinct from the approach usually followed in solving technical problems where scientists seek to isolate the problem and work within a system as closed as possible. Paul notes, "When we think dialectically we are guided by principles, not procedures."

11 **Sternberg, Robert J.** "How Can We Teach Intelligence?" *Educational Leadership,* 41,1 (September 1984) pp. 38-48. EJ number not yet assigned.

Sternberg reports that, contrary to the assumptions reflected in IQ tests, intelligence is not a fixed, immutable characteristic of an individual. Rather, recent research has shown intelligence can be taught. Three programs that claim to do just that are the Instrumental Enrichment program, the Philosophy for Children program, and the Chicago Mastery Learning Reading program.

Instrumental Enrichment is intended to improve cognitive functioning related to the way students perceive, elaborate on, and express information. The exercises train students with tasks very similar to those encountered in a traditional intelligence test. It does not attempt to teach either specific items of information or formal, operational, abstract thinking, says Sternberg.

"Philosophy for Children consists of a series of texts in which fictional children spend a considerable portion of their time thinking about thinking and about ways in which better thinking can be distinguished from poorer thinking." As students read the texts and engage in classroom discussions and exercises that follow the reading, they begin to identify with the characters and thus "to join in the kinds of thinking depicted in the program." Thinking skills such as formulating cause-effect relationships, identifying underlying assumptions, and working w.. analogies are integrated into different content areas such as art, social studies, and science, says Sternberg.

The Chicago Mastery Learning Reading program "emphasizes learning strategies and study skills." Sternberg notes that "the instructional units beg.. with simple, concrete, literal and familiar material and proceed to the more complex, abstract, inexplicit and unfamiliar material." Like the two previously mentioned programs, this one also directly teaches cognitive skills. But it differs in that it resembles typical classroom curriculum more than the other two; in fact, it fits in as the reading component of the curriculum. Sternberg says, "Instruction is done in groups, with individual remediation as necessary." One of the ways that it is said to differ from traditional instruction is in the frequent use of systematic formative and diagnostic testing within each instructional unit.

12 **Vye, Nancy J., and Bransford, John D.** "Programs for Teaching Thinking." *Educational Leadership,* 39,1, (October 1981), pp.26-28. EJ 253 750.

Consider the following problem: "There are three separate, equal-size boxes, and inside each box there are two separate small boxes. Inside each of the small boxes there are four even smaller boxes. How many boxes are there altogether?" Vye and Bransford note that "the only mathematics required for the solution of this problem is simple addition. Nevertheless, many students who can add columns of numbers have difficulty determining which numbers they should add (some merely add three plus two plus four)."

The authors argue that students need more than just feedback on whether their answer was right or wrong. Teachers need to help students analyze the processes involved in solving problems. "Students need to be helped to analyze and evaluate their own thought processes so they can avoid potential errors." Developers of "thinking skills" programs are attempting to do just that, say Vye and Bransford.

The authors report on three such programs: Analytical Reasoning, Instrumental Enrichment, and Philosophy for Children. Analytical Reasoning encourages students to "think aloud." Working in pairs, one student assumes the role of the problem solver, while the other plays a friendly critic. As the problem solver verbalizes his or her thoughts while solving the problem, the critic "monitors these thoughts to ensure that the problem solver reads the problem correctly, explicitly notes each step toward solution, and checks the accuracy of each step in the thinking."

Instrumental Enrichment and Philosophy for Children also emphasize thinking processes. But instead of thinking aloud, students in these programs "analyze their strategies for solving various problems" and then "evaluate the strategies as a group." Vye and Bransford observe that "students' errors often stem from their failure to adequately specify the nature of a problem and to identify the information relevant to its solution, so a great deal of emphasis is placed on problem definition."

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